

Claims

1) An apparatus for refueling an aircraft in-flight, the apparatus comprising:

a refueling receptacle on the aircraft, the receptacle being adapted for
5 receiving a separate fuel probe when refueling the aircraft in-flight;

at least one sensor on the receptacle, the sensor being adapted for sensing forces acting on the receptacle by a fuel probe received by the receptacle when refueling the aircraft in-flight; and,

a control coupler on the aircraft, the control coupler communicating
10 with the sensor and being adapted for controlling movement of the aircraft in-flight in response to forces acting on the receptacle that are sensed by the sensor.

2) The apparatus of Claim 1, further comprising:
15 the aircraft being an unmanned aircraft.

3) The apparatus of Claim 1, further comprising:
the sensor being one of a plurality of sensors on the receptacle, the plurality of sensors being adapted for sensing forces acting on the receptacle
20 by a fuel probe received by the receptacle.

- 4) The apparatus of Claim 3, further comprising:
each sensor of the plurality of sensors being adapted for sensing a magnitude of an external force acting on the receptacle and a direction of the external force acting on the receptacle.

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- 5) The apparatus of Claim 3, further comprising:
the plurality of sensors includes at least three sensors that are positioned on the receptacle to sense external forces acting on the receptacle along three mutually perpendicular axes.

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- 6) The apparatus of Claim 5, further comprising:
each of the three sensors being adapted for sensing external forces acting on the receptacle in two directions along each of the three mutually perpendicular axes.

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- 7) The apparatus of Claim 1, further comprising:
the aircraft having a center of gravity; and,
the control coupler being adapted for transforming forces acting on the receptacle into equivalent external forces and moments acting on the aircraft center of gravity.

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- 8) The apparatus of Claim 1, further comprising:
the sensor being adapted for sensing a magnitude and direction of external forces acting on the receptacle; and,

the control coupler being adapted for controlling movement of the aircraft in a direction that eliminates the external force acting on the receptacle.

- 5 9) The apparatus of Claim 1, further comprising:

the aircraft having a control architecture that includes an outer-loop guidance component, an inner-loop guidance component, and a control surface mixer; and,

the control coupler communicating with the aircraft control architecture.

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- 10) The apparatus of Claim 9, further comprising:

the control coupler communicating with the control surface mixer.

- 11) The apparatus of Claim 9, further comprising:

15 the control coupler being adapted for overriding the aircraft outer-loop guidance component.

- 12) The apparatus of Claim 1, further comprising:

the receptacle having a center axis that defines opposite positive and
20 negative receptacle X-axis directions along the center axis, and defines
opposite positive and negative receptacle Y-axis directions that are
perpendicular to the receptacle X-axis directions, and defines opposite
positive and negative receptacle Z-axis directions that are perpendicular to
both the receptacle X-axis directions and the receptacle Y-axis directions;

and the sensor being one of a plurality of sensors that include an X-axis sensor that senses forces acting on the receptacle along the receptacle X-axis, a Y-axis sensor that senses forces acting on the receptacle along the receptacle Y-axis, and a Z-axis sensor that senses forces acting on the
5 receptacle along the receptacle Z-axis.

13) The apparatus of Claim 12, further comprising:

the control coupler communicating with the X-axis sensor, the Y-axis sensor and the Z-axis sensor to receive signals from the sensors that are
10 representative of forces acting on the receptacle.

14) The apparatus of Claim 13, further comprising:

the X-axis sensor, the Y-axis sensor, and the Z-axis sensor being adapted for producing signals that are representative of both a magnitude and
15 a direction of forces acting on the receptacle.

15) A method of refueling an aircraft in-flight, the method comprising:

providing a refueling receptacle on the aircraft;
receiving a separate refueling probe by the receptacle when refueling
20 the aircraft in-flight;
providing at least one sensor on the receptacle;
with the sensor, sensing forces acting on the receptacle from the refueling probe received by the receptacle;

providing a control coupler on the aircraft that receives signals from the sensor that are representative of the forces acting on the receptacle; and,
with the control coupler, controlling movements of the aircraft in-flight that cause the forces acting on the receptacle to be reduced.

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16) The method of Claim 15, further comprising:
with the control coupler, controlling movements of the aircraft by changing acceleration of the aircraft.

10 17) The method of Claim 15, further comprising:
with the sensor, sensing both a magnitude and a direction of forces acting on the receptacle.

18) The method of Claim 15, further comprising:
15 the aircraft being an unmanned aircraft.

19) The method of Claim 15, further comprising:
providing a plurality of sensors on the receptacle that sense forces acting on the receptacle along three mutually perpendicular axes.

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20) A method of refueling an unmanned aircraft in-flight, the method comprising:
providing a refueling receptacle on the aircraft, the refueling receptacle having a center axis that defines opposite positive and negative receptacle X-

- axis directions along the receptacle center axis, and defines opposite positive and negative receptacle Y-axis directions that are perpendicular to the receptacle X-axis directions, and defines opposite positive and negative receptacle Z-axis directions that are perpendicular to both the receptacle X-
- 5 axis directions and the receptacle Y-axis directions;
- providing an X-axis sensor on the receptacle that senses forces acting on the receptacle along the receptacle X-axis;
- providing a Y-axis sensor on the receptacle that senses forces acting on the receptacle along the receptacle Y-axis;
- 10 providing a Z-axis sensor on the receptacle that senses forces acting on the receptacle along the receptacle Z-axis;
- providing a control coupler on the aircraft that communicates with the X-axis sensor, the Y-axis sensor, and the Z-axis sensor to receive signals from the sensors that are representative of forces acting on the receptacle,
- 15 the control coupler being operative to control movement of the aircraft to reduce the signals that are representative of forces acting on the receptacle.